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ABSTRACT

Learning Management Systems (LMS) represent a rapidly expanding domain of e-learning touted to bring great efficiencies and effectiveness to organizations through growth and training of employees. Their presence is made possible by recent gains in instructional technology of power, speed, and accessibility, enhanced by the demise of the limitations of microcomputers of the 1980s. There is little current LMS research to support the marketing claims made by system vendors, with respect to either organizational or individual change and effectiveness. LMSs, in fact, have a rich history in theory and practice, derived from numerous projects and studies completed during the days before microcomputers, in the time of mainframes, which devoured vast sums of money and programming expertise. This paper examines key elements of the seminal history of computer-managed instruction (CMI), including developmental writings, theoretical underpinnings, and applications in various fields. (Contains 16 references.) (Author/AEF)

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CMI Theory and Practice: Historical Roots of Learning Management Systems

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Abstract: Learning Management Systems (LMS) represent a rapidly expanding domain of e-learning which are touted to bring great efficiencies and effectiveness to organizations through growth and training of employees. Their presence is made possible by recent gains in instructional technology of power, speed, and accessibility, enhanced by the demise of the limitations of microcomputers of the 1980s. There is little current LMS research to support the marketing claims made by system vendors, with respect to either organizational or individual change and effectiveness. LMSs in fact have a rich history in theory and practice, derived from numerous projects and studies completed during the days BC (before microcomputers), when mainframes roamed the earth, devouring vast sums of money and programming expertise. This paper will examine key elements of the seminal history of computer-managed instruction (CMI), including developmental writings, theoretical underpinnings, and applications in various fields. It is the hope that lessons will be drawn from this work which may inform those engaged in reinventing the wheel.

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LMS and CMI

Learning management systems are computer based database and presentation systems which manage the entire instructional program and learning progress of employees with respect to the competencies specified by the goals and objectives of an organization. Computer managed instruction systems, from which LMSs are derived, manage the learning program of individuals in terms of 1) diagnostic assessment of performance relative to some standards and 2) prescriptive assignment of learning resources relevant to those standards. See Figure 1 for a generalized CMI system.

Historically there are two major defining sources for CMI systems. The first is a paper by Baker (1981) in which the functional specifications of a CMI system are laid out. The second is the development of a numerous sophisticated CMI systems, one of which was at the time the most heavily used software package in the Control Data Education Company's repertoire of extensive courseware.

Baker (1981), at the dawn of the microcomputer age, addressed the question of integrating computer based instruction (CBI) into an enduring fabric of educational systems and argued that CMI is the needed tool because "...modern instructional strategies are becoming more complex and thus harder to manage from an instructional and administrative point of view[s]" (p.23). He outlined a system which would address the instructionally-related functions of: 1) data collection, 2) individualized diagnosis and prescription, 3) performance monitoring, 4) scheduling, 5) resource allocation and 6) reporting. In addition, his specifications included computer-related functions of: 1) man-machine interface, 2) database management, 3) and system-generation. His analysis further specified the data requirements as: 1) assessment, 2) diagnostic, 3) prescription, 4) resource and 5) curriculum evaluation. Finally, he specified the hardware requirements in terms of the dominant hardware of the day, the mainframe with dumb terminals and optical scanning devices attached.

Meanwhile, Michael Allen, creator of Authorware, designed a CMI system for use with PLATO, which was at the time a mainframe system entirely devoted to the delivery of instruction and training. Called PLATO Learning Management (PLM), this system was designed to work with most curricula and

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was employed to manage the massive amount of courseware produced by the CDC Education Corporation. PLM was also available for PLATO clients to integrate with their custom courseware programs.

Other organizations and individuals developed CMI systems which had varying degrees of impact on their organizations. A CMI system was custom-developed for the University of Illinois PLATO system, which was the original system that became the basis for the CDC PLATO system. The U.S. Air Force developed an optical-scan based CMI system (Automated Instructional Systems) for training of personnel who supported military aircraft. This system evolved over the years into one currently used to train fighter pilots. Several of these systems used by the military were reviewed by Tennyson and Park (1984).

Learning theory

Today's LMS vendors generally do not elaborate the learning theory basis upon which their systems operate, suggesting the lack of such background. What is the learning theory basis of early CMI systems? Since most CMI mainframe systems originated in higher education, it is not surprising they embodied theories of how people learn. Here is a brief summary of five theory-based strategies which have influenced CMI: metacognition, individual responsibility, error correction in human judgment, individualized instruction and deep cognitive processing. Note that these theories may have been modified or superceded since their use as a basis for CMI.

Metacognition

> Metacognitive experiences involve the use of metacognitive strategies or metacognitive regulation (Brown, 1987). Metacognitive strategies are sequential processes that one uses to control cognitive activities, and to ensure that a cognitive goal (e.g., understanding a text) has been met. These processes help to regulate and oversee learning, and consist of planning and monitoring cognitive activities, as well as checking the outcomes of those activities (Livingston, 1997).
>
> For example, after reading a paragraph in a text a learner may question herself about the concepts discussed in the paragraph. Her cognitive goal is to understand the text. Self-questioning is a common metacognitive comprehension monitoring strategy. If she finds that she cannot answer her own questions, or that she does not understand the material discussed, she must then determine what needs to be done to ensure that she meets the cognitive goal of understanding the text. She may decide to go back and re-read the paragraph with the goal of being able to answer the questions she had generated. If, after re-reading through the text she can now answer the questions, she may determine that she understands the material (Livingston, 1997).

CMI systems claim to supplement the self-metacognition strategies with objective, second party information. For example Szabo & Forsyth (1994) found that exposure to a CMI system while studying mathematics initially resulted in increased learning but the effect leveled off over time, leading to the hypothesis that CMI provides a metacognitive model which learners adapted to sharpen their study skills through a better understanding of their own learning approaches.

Individual Responsibility

Individual responsibility theory (IRT), individual responsibility for success or failure to learn, comes from research on motivation (Wittrock, 1979) which largely draws on attribution theory and locus of control. In locus of control, achievement has been increased by teaching learners to believe they can influence their destiny in school by their efforts (deCharms, 1972). Instructors and learners are taught they are the origins—people who cause their behavior—rather than pawns or people largely under control of their environment. The latter is often accompanied by feels of helplessness which can interfere with learning.

Attribution theory (Weiner, 1976) is closely related and posits that success and failures in one's life is largely attributable to luck or task difficulty which are variable or stable external causes. Quite often one's attribution beliefs stem not from the school performance results which they attain, but from the manner in which those results are communicated by the instructor and the social structure of the classroom.

One implication for instruction is to provide information about personal levels of performance in an objective and non-threatening environment with the belief that such information can stimulate self-corrective action. Thus, CMI systems have been used to function in an individualized fashion, providing confidential feedback to individuals on their individual pattern of meeting competencies. In addition, they function in an objective fashion, such that learners receive feedback with respect to what they have learned rather than relative to their standing in some comparison group. Such assessments are called criterion-referenced or norm-referenced, respectively, and much has been written about them in the measurement and evaluation literature. Finally, most CMI systems provide paths to learning resources (diagnostics) and the opportunity to return to the assessment portion to improve their performance (Figure 1); this implies some control over the person's environment.

Error Correction in Human Judgment

This theory is based on the observation that people tend to overestimate their own strengths and underestimate their weaknesses, in short, to be poor judges of their own abilities. When learners are placed in a self-paced learning environment, they must often judge whether they have successfully learned the content before they proceed to the next module, which may have the previous one as prerequisite. They can succumb to either prematurely proceeding to the next module, inadequately prepared, or unnecessarily return to the current module and study excessively. Both strategies are at the best inefficient and perhaps ineffective.

This problem is addressed in CMI by giving learners another source of objective information regarding their own progress. When a student finishes a module and has to decide whether to return or go on to the next module, a CMI system allows the learner to complete an objective assessment of his or her level of performance on the objectives of the module. The instantaneous feedback embedded in the exercise provides an unbiased assessment which can be used to fine tune the decision to proceed or not.

Tennyson (1981) developed such a CMI system which he referred to as an advisement system (Advice by Computer), to provide objective advice to learners to use to check their performance decisions. He found that his advisement system resulted in both increased achievement and increased ability to monitor one's own performance.

Individualized Instruction

The theoretical basis of this approach is that individual performance exhibits great variability within a group of learners. For example, the rate at which a defined group of individuals learn typically varies by a ratio of 5 to 1, suggesting the need for self-pacing. Entering knowledge of individuals with respect to content being taught varies significantly, as revealed by course pretest data. This is particularly true of adults who have had wide ranges of experiences and learning compared with adolescent learners. However, classroom-based instructional strategies, to be administered efficiently, require that all learners cover the same material in the class at the same time and same pace. This leads to inefficiencies and reduced motivation to learn.

Competency-based learning/mastery imply a repeated cycle of instruction and testing until competencies have been met. The iterative nature of the computer offers significant potential to accommodate this cycle through its ability to administer exams with little or no instructor intervention and to clerically process the data and present the performance results in a summary form to the instructor.

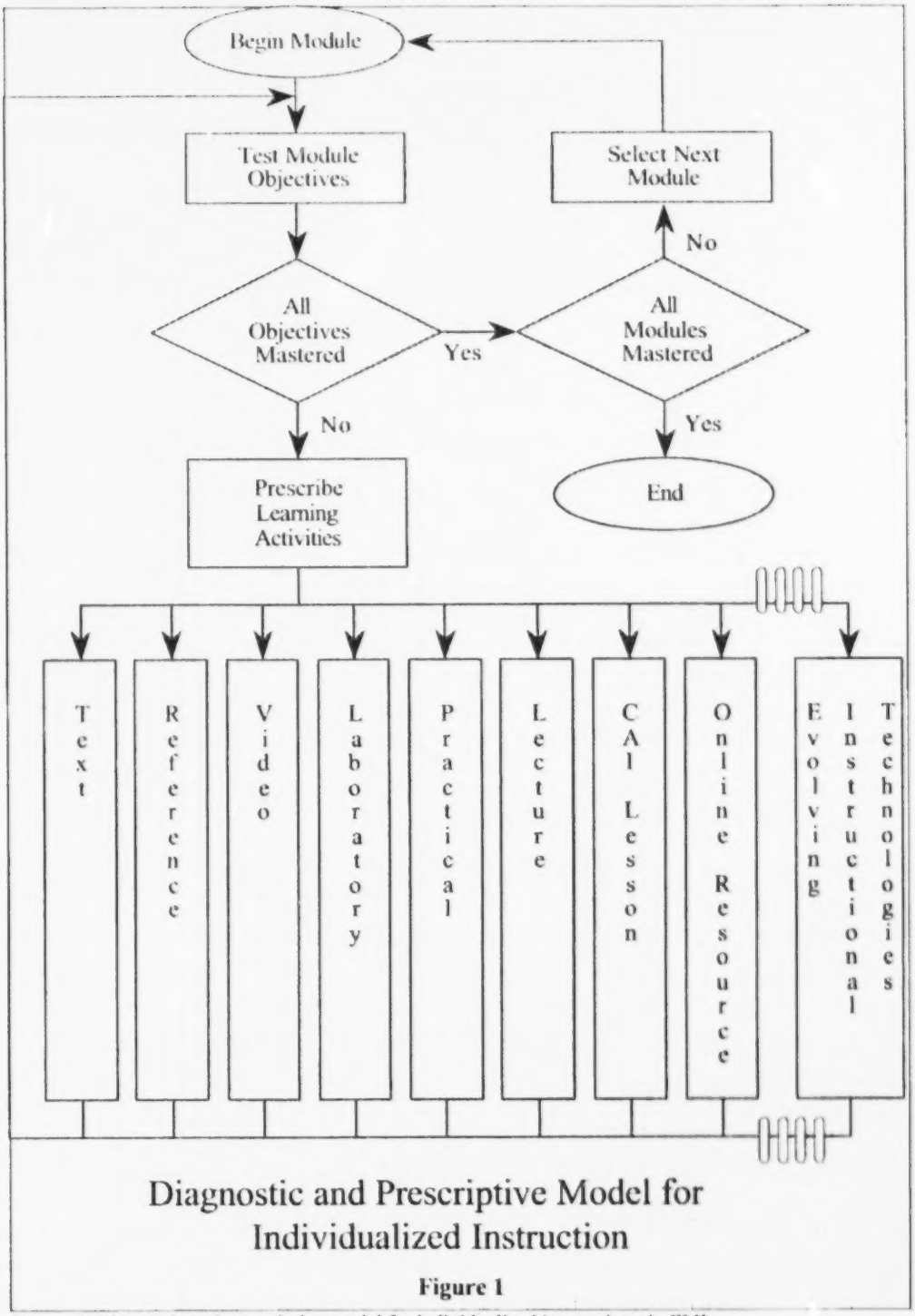

Figure 1: Diagnostic and prescriptive model for individualized instruction via CMI.

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CMI systems can support individualization in several ways. First, each student can be tested over a unique set of competencies as tailored to that person's job classification and performance. The testing can be done through computer-administered instruments, evaluation by expert judges, or both. The study assignments resulting from deficiencies are tailored precisely to those deficiencies. Generally CMI systems accommodate individual differences by allowing learners to: 1) proceed through instruction at a comfortable rate of learning, 2) skip those competencies where they can demonstrate mastery, thus greatly reducing time spent in instruction, 3) start at any point in the instructional sequence, and 4) obtain specific performance indicators and suggestions for what to study to alleviate any performance deficiencies (See Figure 1). Furthermore, this data is tracked, stored and can be recalled and reported for progress and due diligence reports for the individual, training unit, organization and certification agency.

CMI can also accommodate performance competencies requiring demonstration of a performance skill. Once evaluated by a qualified trainer or supervisor, the results can be entered into the system to maintain a comprehensive tracking and reporting system.

A system based on PLATO Learning Management was implemented in the Edmonton Police Department during the 1980s. Officers were able to skip individual units of instruction if their performance on a pretest indicated mastery. A follow up study (Szabo, 1987) indicated the system was instrumental in increasing paper and pencil achievement, on the job performance and reducing training time by 25 percent, resulting in a savings of approximately $350,000 over a 5 year period.

A massive use of PLM involved the basic skills adult literacy curricula (grades 3-8 and 9-10). Pretests indicate what grade and month level a learner should begin in the basic skills of mathematics, science, social studies, reading and English. Student's programs were individually monitored and extensive feedback provided to guide both learners and instructors. Sample reports from this program can be found in Szabo (1994).

Deep Cognitive Processing

This approach evolves from the information processing theory of learning that says that learning is affected by the structure of the mind as perceived to be like an information processing system. A simplistic view reveals its components to be: 1) a system to perceive the external world, 2) short term memory (STM) in which to temporarily store the information which successfully navigates the perceptual system, 3) a long term memory storage system (LTM) and 4) a working memory (WM) where information from STM and LTM are mixed in order to update LTM.

A known problem is that STM is severely limited in the amount of information it can hold (5 plus or minus 2 'bits' of information), and it regularly dumps information which cannot be processed in wm sufficiently to become part of ltm. To solve this problem, theorists have proposed that the process of dumping information into stm be regularly and systematically interrupted and interspersed with activities which stimulate wm. This 'forces' the processing of information by the learner to minimize its loss from stm before it can be integrated into ltm.

An example of this concept is as follows. Instead of assigning 100 pages of reading material, it is assigned in 10 page blocks, or something equivalent, depending on the density of information. After reading each 10 page block, the learner signs on to a CMI program which provides a diagnostic and prescriptive assessment of the information to be learned from those ten pages. In other words, the "dumping" of information into the stm is interrupted by cognitive processing activities, which should enhance learning. Further cognitive processing is provided by arranging the feedback such that the location of the answers are provided rather than the answers themselves. This requires additional cognitive processing. Finally, if the questions are pitched at a high cognitive level, it is argued that deep cognitive processing occurs and learning is improved.

Anderson et. al., (1975) developed a computer assisted study management system (CAISMS) based on the deep cognitive processing theory for use in an economics course. A well-controlled experimental research study compared learners who used CAISMS with those who didn't. Learners in the treatment group read study assignments and immediately completed on-line tests to assess their learning. Successful learning allowed a student to proceed through the syllabus, while unsuccessful learning required continued study of material already covered with retest opportunities.

Results from this study indicated that learners using CAISMS scored significantly higher on all course exams. One student's anecdotal comment is worth noting: "I really think CAISMS helped me a lot in this course, if not for anything else, it made me study regularly and be sure I got the right things out of what I read" (p. 8). Attitudes toward the course and method, as measured in the Anderson et al. study were

significantly higher for the CAISMS learners. Attitude scores for learners was improved through the use of CAISMS for large but not for small classes. CAISMS had no overall effect on course completion rate.

A Brief History of CMI Application and Research

Several large-scale projects on managing and individualizing instruction in the 1960s and 1970s found the computer to be valuable in managing instruction: Program for Learning in Accordance with Needs (Flanagan, 1969); Individually Prescribed Instruction (Cooley & Glaser, 1969); and Instructional Management System (Silberman, 1968).

Dozens of mainframe CMI applications have been made over the years with agencies such as United Airlines pilot training, Naval personnel training, and educational courseware at all levels from grade 3 through adult basic education.

A CMI program was developed for a nursing course at the University of Alberta. A controlled study Kot, Skillen & Wales (1986) showed that the CMI group and non-CMI group had equivalent achievement scores and learning times. The instructors in the non-CMI group spent twice as much time per student than the instructors in the CMI group. At the same institution, Boblin & Gibson (1986) reported learners in the CMI class achieved higher marks for all unit tests and final course mark. Because of the lower rate of attrition in the CMI course, the authors raise the possibility that the course with CMI would not function well as the 'first screen' for learners in the program.

In terms of development costs, Fahy (personal correspondence, November 1987) indicated that a CMI application, using the existing PLM system and existing learning resources could be developed in 5 minutes per test item. Szabo & Estes (1978) compared costs of developing computer managed and computer assisted instruction in nursing courses and concluded that the former takes one-fourth the development time compared with the latter.

Szabo & Montgomerie (1992) made the following conclusions a decade ago.

> Much of the research on CBI includes components of CMI, so it is difficult to isolate the specific contribution made by CMI to the effectiveness of the instruction, attitudes towards computers, etc...The very strong impression gained from a review of the studies reported here is that CMI has shown to be efficient, effective and relatively easy to develop compared with other forms of mediated instruction. Experience indicates that CMI can be implemented by instructors, working alone or in teams ...A comment often made within developmental teams is that one of the major benefits is the logical re-thinking of a course or curriculum required when implementing CMI...CMI has been shown to be useful in the context of existing courses (e.g., Anderson, et al, 1975; Boblin & Gibson, 1986) as well as in brand new courses (Szabo & Estes, 1978). It has also been used as mainline instruction or as supplementary instruction, (the latter required or optional). CMI has been successfully applied over a wide range of content areas, ranging from nursing to special education to pilot training (p. 127-130).

Two final observations arise from the 1992 article. The first "Although not systematically reported here, there is a rapid proliferation of microcomputer based CMI applications and programs as people begin to apply the microcomputer to the management of student learning" (p. 130) did not happen as rapidly as predicted. It apparently had to wait for the advent of a system which includes worldwide computer networks, massive database storage facilities, creation of CMI software, new programming languages and the Internet.

The second observation "The only bit of advice we would offer here is for aspiring developers to carefully examine the features of the most outstanding mainframe-based CMI systems and avoid reinvention of the CMI wheel (p. 130) is still the recommendation of choice, with the proviso that the focus be LMSs rather than CMI.

Recent Examples

New York-based Vuepoint Corporation worked with Toyota to train its 88,000 Toyota and Lexus dealers and corporate associates in the United States. Vuepoint will design and implement an enterprise-wide e-learning system that Toyota projects will pay for itself within 24 months and realize an estimated

net savings of $11.9 million over five years. Vuepoint Learning System 3.0 will provide the base training infrastructure for University of Toyota and allow it to consolidate numerous systems. The platform integrates LCMS, LMS, authoring, and virtual collaboration. Consultant Sapient Corporation is partnering on the implementation. (Learning Circuits Express, 2002).

The Thomson Corporation is celebrating a new multi-year contract to provide e-learning courses to General Motors employees via General Motors University. Thomson's Cardean University, which collaborates with leading business schools, will expand its relationship with GM U to provide an e-MBA program along with custom courses for GM's automotive business. GM already uses some of Cardean's online executive and management development courses. The agreement to expand the full suite of Cardean products to global GM employees follows the successful integration initiated last April of the GMU/Cardean HR Skills for Success program. (Learning Circuits Express, 2002).

Ceridian Canada, Canada's leading payroll management company, has selected San Francisco-based Ninth House to supply online management training for a performance improvement initiative that will focus on managers and customer service. Ninth House courses, simulations, and Instant Advice tool are being rolled out to Ceridian managers throughout the country as part of a program to strengthen Ceridian's management team across a dispersed workforce. (Learning Circuits Express, 2002).

Delta Air Lines has selected Pathlore's LMS to plan, deliver, and manage its training programs. The initiative debuts in May with an enterprise-wide simulation workshop on business literacy. Delta also will use Pathlore's LMS to deploy blended-learning programs. Other training initiatives will include skills management, corporate compliance courseware, a content repository, and professional development. (Learning Circuits Express, 2002).

Summary

Learning management systems have emerged from the ashes of early mainframe-based CMI systems, thanks to the LAN, WAN, Intranet and Internet, driven by large databases in servers. Touted for their ROI, often without substantiation, LMSs possess a rich heritage in learning theory, which has largely been lost or understated by commercial ventures intent on developing systems to manage the corporate training program and hopefully provide increased organizational efficiency. Several benefits have been attributed to LMS. It has been claimed that they can:

1. reduce costs through decreased training redundancy and reduced operational errors and down-time,
2. maximize efficiency through integrating into one system safety issues, operating procedures, maintenance packages, environmental standards, and job reference. This one systems makes auditing easier and less expensive, and
3. leverage existing resources through including established policies and procedures; utilizing existing training material and links to "off-the-shelf" commercial computer-based courseware.

A fair question to ask is What evidence is there to support these claims? Several research questions arise from this exercise.

Is learning (attainment of knowledge, skill and attitudinal competencies) enhanced through the use of a Learning Management System?

Does the addition of a Learning Management System impact the structure or culture of an organization? For example, does it result better alignment between corporate mission, goals, and employee competencies?

Can a Learning Management System be expected to generate a ROI? If so, what magnitude might be expected?

Is there value in reviewing recent developments in learning theory (since the days of the original CMI) to ascertain the appropriateness of LMS' applications?

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